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I. SEMIANNUAL ENVIRONMENTAL MONITORING REPORT

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II. Introduction

The National Accelerator Laboratory facility is a 200 GeV proton synchrotron. The primary purpose of the installation is fundamental research in high-energy physics. The 1.2 mile diameter main accelerator (Fig. 1) receives 8 GeV protons from a booster accelerator which is fed by a 200 MeV linear accelerator (Linac). The 200 GeV beam extracted from the main accelerator can be taken to three different experimental areas (Fig. 2), only one of which, the Neutrino Laboratory, has received beam to date. Radioactivity is produced as a result of the interaction of the accelerated protons with matter. Most of this radioactivity will be contained in insoluble shields and beam dumps. Operation of the accelerator at full design energy and intensity will produce some radiation which penetrates the shielding as well as some air-borne activity. Also, some radioactivation of soil will occur. Thus, a broad program of environmental monitoring is being maintained.

III. Summary

During the latter part of the reporting period, the first external beam experiment was performed. A 200 GeV proton beam was extracted from the accelerator and delivered to the 30 inch bubble chamber more than one mile from the accelerator. Since the beam intensity was one ten-thousandth of the maximum design intensity, the amount of radioactivity produced outside the shields and dumps was negligible.

Water samples were taken from all sumps along the beam line (Fig. 2) before the beam was extracted in order to establish normal background levels. These samples were analyzed by U. S. Testing Company, Inc. of Richland, Washington. Samples were also taken during and after the experiment from sumps at locations N1 and N2 (Fig. 1). These sumps collect water from the area surrounding the 400m meson decay pipe where most of the beam was deposited. A cursory examination of these waters at the National Accelerator Laboratory revealed no accelerator produced gamma ray activity. Also, samples were shipped to U. S. Testing Company for thorough examination. Results just received indicate that no accelerator produced radioisotopes were present.

A central monitoring station is maintained for detecting penetrating radiation. No evidence of accelerator produced radiation was seen by any detector in the station during the entire period, which included the 200 GeV external beam experiment. The three gamma sensitive monitors (aluminum-argon ion chamber, tissue-equivalent ion chamber, and NaI(Tl) crystal) have consistently indicated natural-background-level exposures of approximately 0.006 milliRoentgens/hour except for brief

periods discussed in Section IV. The neutron monitors have indicated an average flux of approximately 17 n/(cm^2-hr), which is consistent with the expected cosmic-ray neutron background. This corresponds to a neutron dose of approximately 0.0005 mrem/hr.

Accelerator operations during this reporting period were at too low an intensity to produce appreciable quantities of air-borne radioactivity. Since low levels of Beryllium-7 (53 day half-life) activity were detected in closed-loop magnet cooling water systems for the booster and main accelerator, an extensive program of water sampling was carried out for both surface and ground waters. No measurable concentrations of accelerator produced radionuclides were found.

There were no unusual incidents or releases during the reporting period. In addition, there were no nonradioactive materials produced in quantities which could pollute the environment, and there were no abnormal natural occurrences which could have resulted from or have had some impact upon the facility or its operation.

IV. Monitoring, Data Collection, Analysis and Evaluation

The three types of accelerator produced radiation meriting monitoring for environmental purposes are discussed below.

A. Penetrating Radiation

Operation of the accelerator at full design energy and intensity will inevitably result in production of some penetrating radiation (primarily neutrons and muons) outside the shielding. Although the shielding has been designed to be adequate for foreseeable circumstances, monitoring for purposes of determining actual radiation levels both on and off the site is necessary.

A central monitoring station is maintained in the NAL site "village" for detecting penetrating radiation. The monitoring equipment consists of five major components.

1. Aluminum-Argon ionization chamber. This chamber is mostly sensitive to muons and gammas, and much less sensitive to neutrons. The data is recorded as daily integrals of the ionization current. A continuous strip-chart record of ionization current is also made.

2. Tissue-equivalent ionization chamber. This chamber is sensitive to neutrons as well as gammas and directly ionizing radiations. The data is recorded as daily integrals of the ionization current and as a strip-chart record of ionization current.

3. A 3 in x 3 in NaI(Tl) radiation ratemeter. This device is sensitive primarily to gamma radiation above 100 keV. The data is recorded as daily integrals of the counts and as a strip-chart record of count rate.

4. Bonner spectrometer. This device is an array of moderating hydrogenous spheres with thermal-neutron sensitive $Li^6I(Eu)$ scintillators located at the center of each sphere. The data is recorded as the daily integral of counts in each detector. It may be unfolded by a computer program to obtain the neutron flux and dose.

5. Precision reproducible (DePangher) long counter. This device is a BF_3 proportional counter moderated by polyethylene to obtain an essentially flat energy response to neutrons. The count rate from this device is thus a measure of neutron flux. The data is recorded as daily integrals of neutron counts.

A number of short periods of increased radiation levels have been observed since the monitoring station was put into operation, but no correlation with accelerator production of penetrating radiation has been found. The origin of this radiation is being sought. With the exception of these periods which last for several hours, typically, and occur randomly days or weeks apart, the radiation level has remained relatively stable throughout the reporting period. The results were given in Section III.

B. Air-borne Radioactivity

Under normal operation of certain of the beam dumps and target boxes, radioactivation of air may occur. Monitoring of such activation will be carried out for purposes of personnel exposure control. Under no circumstances is the off-site concentration of air-borne radioactivity expected to approach the limits set forth in the applicable standards.

Accelerator operations during this reporting period were at too low an intensity to produce appreciable quantities of air-borne radioactivity. Air-monitoring of radioactivity released during the repair of magnets removed from the main accelerator was performed and minute quantities of Beryllium-7 and Manganese-54 were detected. In each case the concentrations found were less than one percent of the maximum permissible concentration.

C. Water-borne Radioactivity

During accelerator operations, some radioactivation of the soil will occur. Leaching of these radionuclides into the ground water provides a possible mechanism for transport of NAL produced radionuclides into surface run-off waters. Also, a very small fraction of these radionuclides may reach the aquifer. Hence, a broad program of ground water monitoring for radioactivity is maintained.

Monthly water samples were taken at various locations on the site and analyzed for the presence of those radionuclides which have been experimentally determined to be produced and to be leachable from NAL soils in measurable quantities.

The water sampling locations were chosen to sample two ground water systems:

1. Surface and near-surface waters. These samples were taken from sumps which collect water in the vicinity of accelerator components and from on-site streams and industrial holding ponds.

2. Silurian aquifer. These samples were taken from farm wells which tap the 70 foot silurian dolomite aquifer which is a prime water supply for many private residences in the area.

The sample analysis service was contracted to U. S. Testing Company (Richland Laboratory, Richland, Washington). All monthly sample shipments contained one unidentified sample to which known concentrations of radionuclides had been added. The agreement of the reported concentrations with the known concentrations for these control samples provided verification of compliance with the analysis specifications. The specifications for these analyses are given in Section V.

The locations of the sampling points within the boundaries of the site are shown in Figures 1 and 2. They are further described in Table 1 and elevations from which ground water is collected are given in Table 2. The results of the analyses are tabulated in Table 3. No measurable concentrations of accelerator produced radionuclides were found. Water samples were also taken from water supplies in several of the surrounding communities to establish background levels for future reference.

V. References

The concentration guides used in the analyses of the water samples were taken from the Atomic Energy Commission Manual, Chapter 0524, Annex A, Table II, Column 2 (Water in Uncontrolled Areas) and reduced by a factor of three as appropriate for a suitable sample of exposed population. The smaller of the values given for soluble and insoluble forms has been used in each case. The specifications are given in Table 4. The concentration guides for air-borne activity were taken from the same source, Table II, Column 1 (Concentrations in Air in Uncontrolled Areas), and divided by a factor of three for application to populations. The appropriate standard for penetrating radiation applied to populations was taken from the AEC Manual, Chapter 0524, Paragraph II.A: 0.17 rem/year (exposure to whole body, gonads or bone marrow).

Table 1
Description of Sampling Locations

Designation	Description	Water System Sampled
A1,A2,B1,C1, C2,D1,E1,E2, F1	Sumps adjacent to Main Accelerator enclosure	Shallow ground water from footings
g1,G1,G2,G3	Sumps along beam line between Transfer Hall and Neutrino Lab Front-end enclosure	Shallow ground water from footings
H1	Central Utilities Building Cooling Pond	Industrial cooling water
H2A,H2B,H2C, H2D,H2E,H2F	Main Accelerator Cooling Pond	Industrial cooling water
Mf1,MF1,MF2,MF3	Sumps along beam line between Transfer Hall and Meson Lab Front-end enclosure	Shallow ground water from footings
N1	Sump in Neutrino Lab Front-end enclosure	Shallow ground water collected in decay pipe underdrains
N2	Sump in Neutrino Lab Enclosure 100	Shallow ground water collected in decay pipe underdrains
PE1,PE2	Sumps along beam line between Transfer Hall and Proton Lab Front-end enclosure	Shallow ground water from footings
R1	Ferry Creek	Surface water
R2	Kress Creek	Surface water
R3	Indian Creek	Surface water
S1,S5,S12,S21	Sumps adjacent to Booster enclosure	Shallow ground water from footings
T1	Sump adjacent to extraction area in Transfer Hall	Shallow ground water from footings
V	NAL Village water supply	Silurian aquifer
W4,W7,W21,W29,W38, W43,W49,W50,W52, W55,W59,W64,W66, W68,W74,W75	Cased farm wells	Silurian aquifer

Table 2

Ground Water Sampling Elevations

A. Approximate Well Water Levels

Designation	Elevation Above Sea Level* (feet)
W7	694
W21	693
W29	701
W38	696
W43	688
W49	708
W50	704
W52	696
W55	690
W59	689
W64	694
W66	708
W68	706
W74	700
W75	711

* Values obtained from Robert T. Sasman, State of Illinois, Water Survey Division, Preliminary Map #2, June 1969.

Table 2

Ground Water Sampling Elevations

B. Elevations of Sump Pit Bottoms

Designation*	Elevation Above Sea Level (feet)
S1, S5, S12, S21	714
A1, A2, B1, C1, C2, D1, E1, E2, F1	714
g1, G1	714
G2	725
G3	732
N1	726
N2	731
Mf1	714
MF1	719
MF2	724
MF3	729
PE1	714
PE2	714
T1	714

* See Table 1 for description.

Table 3

Results of Water Sample Analyses†

Part A - Surface and Ground Water

Month	Jan.	Feb.	Mar.	Apr.	May	June
Batch No.	22	23	24	25	26	27
Location						
A1		None	None	None		
A2	None					
B1		None		None		None
C1			None		None	
C2	None					
D1		None		None		
E1			None		None	
E2	None					
F1		None		None		
g1					None	None
G1					None	None
G2					None	None
G3					None	None
H1	None	None	None	None	None	None
H2A		None				
H2B			None			
H2C				None		
H2D					None	
H2E						None
H2F	None					
Mf1					None	None
MF1					None	None
MF2					None	None
MF3					None	None
N1				None	None	None
N2		None	None	None	None	None
PE1					None	None
PE2					None	None
R1			None			
R2				None		
R3					None	
S1	None	None	None	None	None	None
S5		None	None			
S12			None	None	None	None
S21	None	None		None		
T1			None	None	None	

(Footnotes follow Part B.)

Table 3

Results of Water Sample Analyses†

Part B - Wells

Month	Jan.	Feb.	Mar.	Apr.	May	June
Batch No.	22	23	24	25	26	27
Location						
V						None
W4			None		None	None
W7						None
W21	None	None	None	None	None	None
W29	None				None	
W38		None		None		
W43	None	None	None	None	None	None
W49	None	None	None	None	None	None
W50			None			
W52	None				None	
W55			None			
W59						None
W64				None		
W66		None				None
W68				None		
W74			None			
W75	None				None	

† Interpretation of data entries:

A blank indicates no sample was taken.
"None" means that none of the five radionuclides tested for was observed. Refer to Table 1 for applicable sensitivities.

Well locations are shown on Figure 1 and described in Table 2.
no radionuclides were detected

Table 4

Specifications for the Analyses
of Radionuclides in Water

Radionuclide	Concentration Guide µCi/ml	Specified* Sensitivity µCi/ml	Specified* Precision µCi/ml
Na^{22}	1×10^{-5}	3×10^{-7}	3×10^{-7}
Ca^{45}	3×10^{-6}	3×10^{-7}	3×10^{-7}
Mn^{54}	3.3×10^{-5}	5×10^{-8}	5×10^{-8}
H^{3}	1×10^{-3}	3×10^{-6}	3×10^{-6}
Be^{7}	6.7×10^{-4}	5×10^{-7}	5×10^{-7}

* The precision and sensitivity are stated for the 68% confidence level (one standard deviation).

Figure 1 - Map of Sampling Locations

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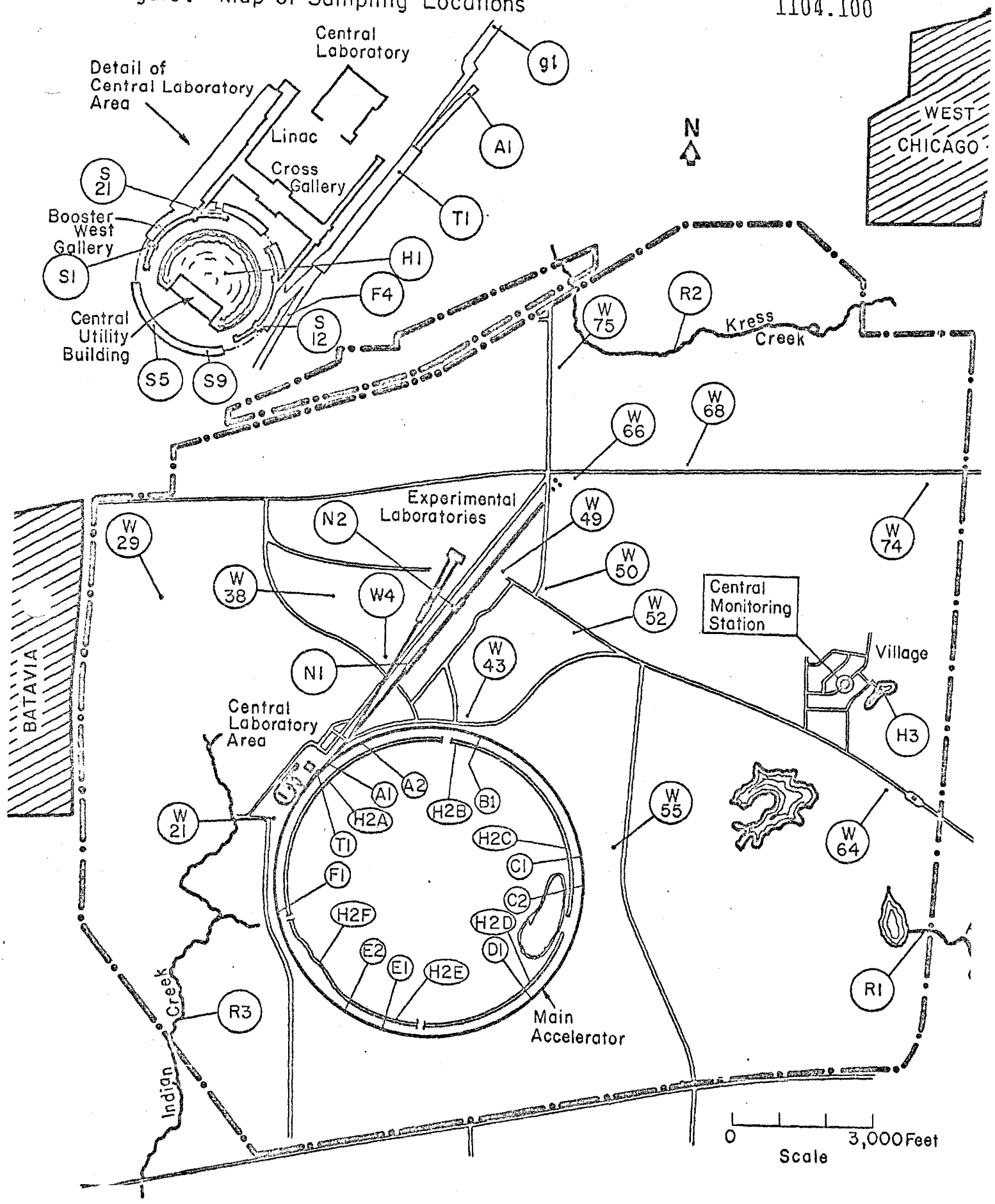

Figure 2 - Sampling Locations Along Beam Lines